CHALMERS

CHALMERS UNIVERSITY OF TECHNOLOGY

Department of technology management and economics
MSc programme in Supply Chain Management

CLOSED BOOK WRITTEN EXAM IN **OPERATIONS PLANNING AND CONTROL TEK 421**

January 14, 2017

Allowed aids: Pen, eraser, Chalmers-approved calculator and English - Any language dictionary are allowed but no operations, logistics, supply chain management dictionary, etc.

Problems: The exam includes seven problems. Formulas and tables are found in the back.

Answers: Write name and problem number on every sheet. Only answer to one problem on each sheet!! Also remember that your handwriting must be possible to read in order to grade your answers!!

Grades: Maximum result is 80 points. 32 points are needed for pass.

Language: You must answer in English.

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Questions: Patrik Jonsson (1336)
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Problem 1 (22 points)

Identify the correct answer for each of the twenty questions. Only one answer is correct per question. Write down your answers (letters, e.g. 1.1b, 1.2d, 1.3c…) on an answer sheet. A correct answer gives 1.1 point.

1.1 Which of the following basic operations strategies assumes the risk of stockouts in exchange for protection against high costs for overtime and capacity maximization?

(a) Level production

(b) Demand shaping/Sell-the-plan

(c) Chase production

(d) Lag strategy

1.2 The plan that provides, in effect, a contractual agreement ensuring salespeople that they can make delivery promises is the

(a) Sales and operations plan
(b) Material requirements plan
(c) Capacity requirements plan
(d) Master production schedule

1.3 The ratio of standard hours of work produced to hours actually worked is called

(a) Effectiveness
(b) Utilization
(c) Efficiency
(d) Historical capacity

1.4 The load shown in a load profile includes all of the following except

(a) All released orders
(b) All firm panned orders
(c) All closed orders
(d) All planned orders

1.5 What data should be a correct representation of historical sales data when used in forecasting future demand?

(a) order entry statistics

(b) delivery statistics

(c) invoicing statistics

(d) none of the above

1.6 What could be a benefit from adjusting a sales management estimated forecast with a forecast generated with intrinsic method?

(a) Forecast makers are being better tied to their forecasts.

(b) Business cycle considerations are being better considered in the forecasting.

(c) Bias is eliminated.

(d) Trends are more easily identified.

1.7 What would the most appropriate strategy be for items with stable and low annual demand?

(a) Use intrinsic forecasting method

(b) Use aggregate forecast to control modules/components and assemble the item to order.

(c) Aggregate stock-keeping and forecast. Consider making the item to order.

(d) Make to order.

1.8 Forecasting trends (select the option that holds the best)…?

(a) is preferably managed with large alpha factors, rather than low beta factors.

(b) is preferably managed with as a multiplicative trend, rather than as an additive trend.

(c) is preferably handled for product groups, rather than for individual products.

(d) should not be combined with seasonal indexes.

1.9 How will the amount of safety stock change if changing from periodic ordering system to re-order point system, if keeping the same order-line fill rate service?

(a) The safety stock will not change
(b) The safety stock will increase
(c) The safety stock will decrease
(d) We cannot tell if and how the safety stock will change. More information is needed.

1.10 Dynamic lot sizing methods are most appropriate when used together with

(A) distribution requirements planning methods

(B) re-order point methods

(C) Kanban methods

(D) run-out time planning methods

1.11 What effect will a change from storing a product at several regional distribution centres to storing it at one central distribution centre and conducting direct distribution to end customers have?

(A) Cycle stock and safety stock will be reduced.

(B) Cycle stock, but not safety stock, will be reduced.

(C) Safety stock, but not cycle stock, will be reduced.

(D) Total cost will increase because of increased transportation costs.

1.12 What safety stock method will result in the lowest cost for a given order line service level for a company?

(A) Cycle service method

(B) Demand fill rate method

(C) Cost optimization method

(D) Any of the methods

1.13 What is most true about material planning?

(A) Kanban is customer order driven.

(B) MRP is a push method.

(C) MRP is forecast driven.

(D) Kanban is a re-order point method.

1.14 A company receives the following customer orders:

I: 50 units in week 8
II: 15 units in week 1
III: 30 units in week 2
IV: 60 units in week 7

Treated in the order they are received and based on the below information, which of the customer orders can be accepted?

On hand inventory: 70 units
Safety stock: 10 units
Lot size: 150 units
Release time fence: 1 week
Demand time fence: 2 weeks
Planning time fence: 6 weeks
Forecast time fence: 7 weeks

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Forecast	50	50	50	50	50	50	50	50
Actual orders	55	30	65	55	50	60	45	40
Projected inventory								
Master production schedule								
Available to promise								

(A) Only order I
(B) Only order I and II
(C) Only order I, II and III
(D) Only order I II and IV

1.15 Based on the below information, what is true about the relationship between economic order quantity (EOQ) and economic run-out time (ERT) lot-sizing method for the 8-week period?

On hand inventory: 0 units
Safety stock: 50 units
Ordering cost: €100 / order
Product cost: €150 / unit
Inventory carrying cost: 15% / year

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Forecast	60	120	80	110	170	140	130	70
Orders								
Stock on hand								

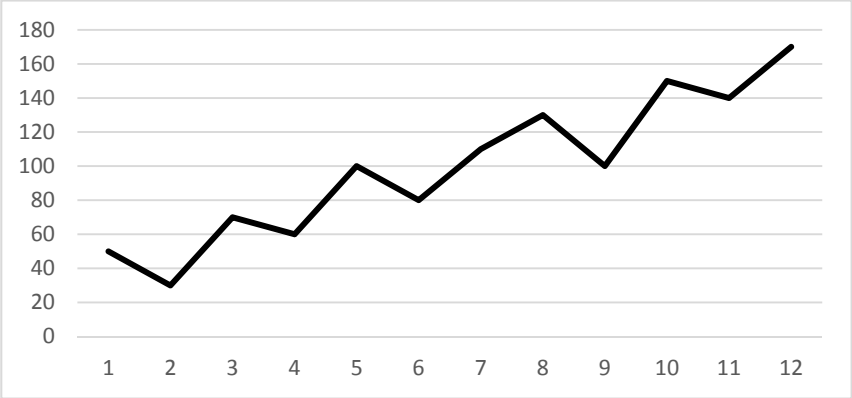
(A) Using EOQ requires less orders than using ERT
(B) Using EOQ requires more orders than using ERT
(C) Using EOQ requires the same amount of orders as using ERT
(D) Impossible to say which method requires most orders

1.16 A company makes three products (A, B and C) to stock. The prioritization of manufacturing orders is based on stock run-out time ratios. How would the products be prioritized given the following information?

Product	**A**	**B**	**C**
Manufacturing lead time (weeks)	6	5	3
Demand per week	1000	200	500
Stock on hand	7000	1500	2500

(A) First A, second B, third C
(B) First A, second C, third B
(C) First C, second A, third B
(D) First C, second B, third A

1.17 When using exponential smoothing for the demand data below, which of the following alternatives are most appropriate?



(A) Select $\alpha = 0.05$
(B) Select $\alpha = 0.15$
(C) Select $\alpha = 0.50$
(D) Select $\alpha = 1.20$

1.18 A company measures the forecasting error of one of its products for the latest year. The result shows a ME (F-D) of -745 units and a MAD (|F-D|) of 770 units. What conclusions can be drawn from the measurement?

I. The forecasting method is appropriate
II. There is a bias in the forecasting method
III. The forecasting method is consistently too high compared to actual demand
IV. The forecasting method is consistently too low compared to actual demand

(A) Only I
(B) Only I and II
(C) Only II and III
(D) Only II and IV

1.19 One parent item Y consist of two items X. Manufacturing lead time is one week and the lot-for-lot method is used to decide lot sizes for both items. Based on the gross requirements for item Y presented below, what is the gross requirements for item X in week 34?

Week	**34**	**35**	**36**	**37**	**38**	**39**
Gross requirements	20	40	10	20	80	40

(A) 10
(B) 20
(C) 40
(D) 80

1.20 A company is using a safety stock of 60 units for one of its products. What is true about the safety stock level?

I. It would increase if the company changed from having a 95% service level to a 98% service level
II. It would increase if the company based the service level on fill rate service instead of cycle service
III. It would increase if the standard deviation of demand changed from 10.7 to 12.4 units

(A) Only I
(B) Only I and II
(C) Only I and III
(D) Only II and III

Problem 2 (9 points)

Describe and explain the main features (5) of sales and operations planning from the coordination point of view.

Problem 3 (9 points)

Describe five contextual factors that increase the complexity of operations planning and control. Explain for each factor how it increases complexity.

Problem 4 (9 points)

Different material planning methods can be used for controlling stock replenishment in a network of one factory, one central warehouse and three regional warehouses. Describe the unique functionalities of (a) material requirements planning logic, (b) run-out time planning logic, (c) periodic ordering logic for controlling the material flow in such a network of warehouses.

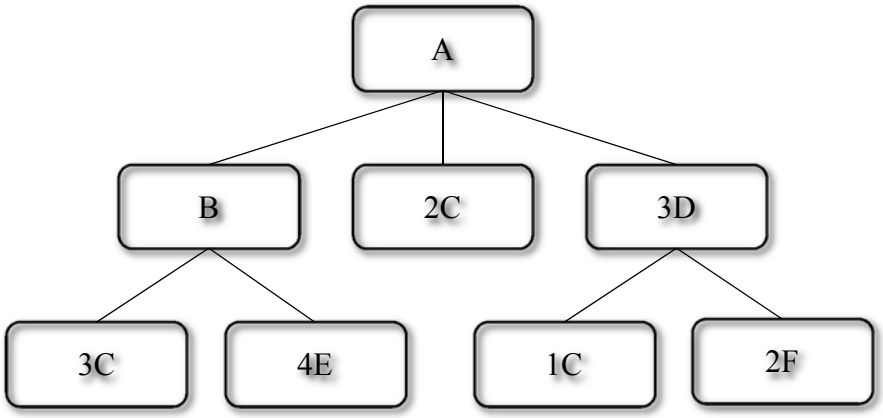
Problem 5 (9 points)

Input/output control is one method for controlling the release of manufacturing orders to the shop floor.

a) Please describe what this method entails.
b) What are the benefits and drawbacks of using this method, compared to the alternatives of order release from planned start times and regulated order release?
c) In what types of production environments is input/output control best applied?

Problem 6 (6 points)
Kanban systems exist in the two general variants of the *one-card kanban system* and the *two-card kanban system*. Please explain the mechanisms in each of these two systems, i.e. explain when and how the kanban cards are moved and what actions they trigger.

Problem 7 (16 points)
A company is producing a product A according to the product tree below.



The company is using a levelled production strategy with an expected cost of €3 587 500 for year 2017. For the production of product A, the company has 22 full time workers and 4 part time workers (working 30%, 40%, 50% and 80% respectively) and a full time worker produces 15 products each week. In the beginning of the year, the inventory level corresponded to 1 500 products, however the company does not plan to have any ending inventory.

a) Based on the forecasted sales and the costs data presented in the tables below, would it be economically reasonable for the company to change to a chase production strategy? Assume unlimited overtime capacity.

Quarter	Forecast
1	6 500
2	2 500
3	1 000
4	7 500

Cost	€
Production cost	200 / unit
Overtime cost	300 /unit
Inventory cost	50 / unit / week
Backorder cost	150 / unit

b) Based on the data from the routing file presented in the table below, what is the capacity requirements for WC300? Base your answer on capacity bill calculations.

Item	Lot size	Work centre	Setup time / batch	Run time / unit	Transport time /batch
A	15	WC100	1h	15 min	5 min
B	15	WC200	2 h	10 min	25 min
C	15	WC300	0,5 h	5 min	10 min
D	45	WC400	1,5 h	10 min	30 min
E	60	WC300	1 h	15 min	15 min
F	90	WC400	0,2 h	10 min	5 min

c) An order of one batch of A is received when only one batch of E and F are available in stores. If prioritised in all work centres (i.e. no queue time or waiting time is considered), what is the least number of days that are needed to produce the order? Base your answer on the normal throughput time (i.e. no lot size splits or setup preparations are possible) and assume that a setup time is needed before every new batch.

Formulas and tables

Forecasting

Exponential smoothing forecast

$$BF(t+1) = \alpha \cdot D(t) + (1-\alpha) \cdot (BF(t) + T(t))$$
$$T(t+1) = \beta \cdot (BF(t+1) - BF(t)) + (1-\beta) \cdot T(t)$$
$$F(t+n) = BF(t+1) + T(t+1) \cdot n$$

$$\alpha = \frac{2}{n+1}$$

where
BF(t+1) = basic forecast for period 1 without considering trends
BF(t) = basic forecast for current period t without considering trends
T(t) = trend for current period t
T(t+1) = trend from period 1
F(t) = forecast demand for current period t
α = Exponential smoothing constant (forecast)
β = Exponential smoothing constant (trend)
n = Number of future periods covered by the forecast

Mean error and MAD

$$ME = \frac{\sum(D-F)}{n}$$
$$ME(t) = \alpha \cdot (F(t) - D(t)) + (1-\alpha) \cdot ME(t-1)$$
$$MAD = \frac{\sum|D-F|}{n}$$
$$MAD(t) = \alpha \cdot |F(t) - D(t)| + (1-\alpha) \cdot MAD(t-1)$$

where:
ME = Mean error
MAD = Mean absolute deviation
D = Demand
F = Forecast
n = Number of periods

ME(t) = ME in period t
MAD(t) = MAD in period t
α = exponential smoothing constant

Inventory control

Standard deviation of demand during lead time

$$\sigma_{DDLT} = \text{standard deviation of demand during lead time} = \sqrt{LT \cdot \sigma_D^2 + \sigma_{LT}^2 \cdot D^2}$$

where LT = average lead time in periods from order to delivery (order cycle)
D = average demand per period
σ_D = standard deviation of demand per period
σ_{LT} = standard deviation of lead time

Service level

$$\text{Service level cycle service in \%} = \left(1 - \frac{\textit{number of inventory cycles with shortage}}{\textit{total number of inventory cycles}}\right) \cdot 100$$

$$\text{Service level demand fill rate in \%} = \left(1 - \frac{\textit{demand not directly fulfilled from inventory}}{\textit{total demand}}\right) \cdot 100$$

$$\text{Demand fill rate} \quad = 1 - \frac{\frac{D}{Q} \cdot \sigma_{DDLT} \cdot E(z)}{D} = 1 - \frac{\sigma_{DDLT} \cdot E(z)}{Q}$$

where D = demand per year
σ_{DDLT} = standard deviation of demand during lead time
Q = average order quantity
E(z) = service loss function

Shortage costs

When assuming that a stock-out results in lost sales:

$$\Phi(k) = \frac{SC}{SC + IC \cdot \frac{Q}{D}}$$

where Φ(k) = probability that stock-out does not occur during an inventory cycle.
k = service factor
Q = order quantity
IC = inventory carrying cost per unit and time period
SC = shortage cost per stock-out occasion
D = demand per time period

If a stock-out results in a rest (remainder) order and delivery on a later occasion, i.e. the stock-out does not lead to lost sales, the following formula should be used:

$$\Phi(k) = 1 - \frac{IC \cdot Q}{D \cdot SC}$$

Safety stock determination

$$SS = k \cdot \sigma$$

where SS = safety stock
k = safety factor
σ = standard deviation of demand during lead time

Kanban

$$n = \frac{D \cdot L \cdot (1 + \alpha)}{a}$$

where:

D = Demand per time unit
L = Lead time
a = Number of pcs of items in the pallet

Periodic ordering system

$$T = D \cdot (R + L) + SS$$

$$Q = T - S$$

where Q = order quantity
T = order-up-to level
D = demand per period
R = reordering interval
L = lead time
SS = safety stock
S = stock on hand

Lot sizing

$$EOQ = \sqrt{\frac{2 \cdot D \cdot S}{I \cdot C}}$$

where:

EOQ = Economic order quantity
D = Demand per period (units per period)
S = Ordering cost per occasion
I = Inventory interest rate (% per time period)
C = Goods value per unit

Tables of distributions
Poisson distribution:

Average demand during lead time	*80 %*	*85 %*	*90 %*	*95 %*	*97 %*	*98 %*	*99 %*
1	1	1	1	2	2	2	3
2	1	1	2	2	3	3	4
3	1	2	2	3	4	4	5
4	2	2	3	3	4	5	5
5	2	2	3	4	5	5	6
6	2	2	3	4	5	5	6
7	2	3	3	5	5	6	7
8	2	3	4	5	6	6	7
9	2	3	4	5	6	7	8
10	3	3	4	5	6	7	8

Note: Service levels and corresponding Poisson distribution.

Normal distribution:

Safety factor	Service level %	Safety factor	Service level %	Safety factor	Service level %	Safety factor	Service Level %
0.00	50.0	0.72	76.4	1.44	92.5	2.16	98.5
0.02	50.8	0.74	77.0	1.46	92.8	2.18	98.5
0.04	51.6	0.76	77.6	1.48	93.1	2.20	98.6
0.06	52.4	0.78	78.2	1.50	93.3	2.22	98.7
0.08	53.2	0.80	78.8	1.52	93.6	2.24	98.7
0.10	54.0	0.82	79.4	1.54	93.8	2.26	98.8
0.12	54.8	0.84	80.0	1.56	94.1	2.28	98.9
0.14	55.6	0.86	80.5	1.58	94.3	2.30	98.9
0.16	56.4	0.88	81.0	1.60	94.5	2.32	99.0
0.18	57.1	0.90	81.6	1.62	94.7	2.34	99.0
0.20	57.9	0.92	82.1	1.64	94.9	2.36	99.1
0.22	58.7	0.94	82.6	1.66	95.2	2.38	99.1
0.24	59.5	0.96	83.1	1.68	95.4	2.40	99.2
0.26	60.3	0.98	83.6	1.70	95.5	2.42	99.2
0.28	61.0	1.00	84.1	1.72	95.7	2.44	99.3
0.30	61.8	1.02	84.6	1.74	95.9	2.46	99.3
0.32	62.6	1.04	85.1	1.76	96.1	2.48	99.3
0.34	63.3	1.06	85.5	1.78	96.2	2.50	99.4
0.36	64.1	1.08	86.0	1.80	96.4	2.52	99.4
0.38	64.8	1.10	86.4	1.82	96.6	2.54	99.4
0.40	65.5	1.12	86.9	1.84	96.7	2.56	99.5
0.42	66.3	1.14	87.3	1.86	96.9	2.58	99.5
0.44	67.0	1.16	87.7	1.88	97.0	2.60	99.5
0.46	67.7	1.18	88.1	1.90	97.1	2.62	99.6
0.48	68.4	1.20	88.5	1.92	97.3	2.64	99.6
0.50	69.1	1.22	88.9	1.94	97.4	2.66	99.6
0.52	69.8	1.24	89.3	1.96	97.5	2.68	99.6
0.54	70.5	1.26	89.6	1.98	97.6	2.70	99.7
0.56	71.2	1.28	90.0	2.00	97.7	2.72	99.7
0.58	71.9	1.30	90.3	2.02	97.8	2.74	99.7
0.60	72.6	1.32	90.7	2.04	97.9	2.76	99.7
0.62	73.2	1.34	91.0	2.06	98.0	2.78	99.7
0.64	73.9	1.36	91.3	2.08	98.1	2.80	99.7
0.66	74.5	1.38	91.6	2.10	98.2	2.82	99.8
0.68	75.2	1.40	91.9	2.12	98.3	2.84	99.8
0.70	75.8	1.42	92.2	2.14	98.4	2.86	99.8

Service loss function E(z):

Safety factor	Service function	Safety factor	Service function	Safety factor	Service function	Safety factor	Service function
0.00	0.3989	0.72	0.1381	1.44	0.0336	2.16	0.0055
0.02	0.3890	0.74	0.1334	1.46	0.0321	2.18	0.0052
0.04	0.3793	0.76	0.1289	1.48	0.0307	2.20	0.0049
0.06	0.3699	0.78	0.1245	1.50	0.0293	2.22	0.0046
0.08	0.3602	0.80	0.1202	1.52	0.0280	2.24	0.0044
0.10	0.3509	0.82	0.1160	1.54	0.0267	2.26	0.0041
0.12	0.3418	0.84	0.1120	1.56	0.0255	2.28	0.0039
0.14	0.3328	0.86	0.1080	1.58	0.0244	2.30	0.0037
0.16	0.3240	0.88	0.1042	1.60	0.0232	2.32	0.0035
0.18	0.3154	0.90	0.1004	1.62	0.0222	2.34	0.0033
0.20	0.3069	0.92	0.0968	1.64	0.0211	2.36	0.0031
0.22	0.2986	0.94	0.0933	1.66	0.0201	2.38	0.0029
0.24	0.2904	0.96	0.0899	1.68	0.0192	2.40	0.0027
0.26	0.2824	0.98	0.0865	1.70	0.0183	2.42	0.0026
0.28	0.2745	1.00	0.0833	1.72	0.0174	2.44	0.0024
0.30	0.2668	1.02	0.0802	1.74	0.0166	2.46	0.0023
0.32	0.2592	1.04	0.0772	1.76	0.0158	2.48	0.0021
0.34	0.2518	1.06	0.0742	1.78	0.0150	2.50	0.0020
0.36	0.2445	1.08	0.0714	1.80	0.0143	2.52	0.0019
0.38	0.2374	1.10	0.0686	1.82	0.0136	2.54	0.0018
0.40	0.2304	1.12	0.0660	1.84	0.0129	2.56	0.0017
0.42	0.2236	1.14	0.0634	1.86	0.0123	2.58	0.0016
0.44	0.2169	1.16	0.0609	1.88	0.0116	2.60	0.0015
0.46	0.2104	1.18	0.0584	1.90	0.0111	2.62	0.0014
0.48	0.2040	1.20	0.0561	1.92	0.0105	2.64	0.0013
0.50	0.1978	1.22	0.0538	1.94	0.0100	2.66	0.0012
0.52	0.1917	1.24	0.0517	1.96	0.0094	2.68	0.0011
0.54	0.1857	1.26	0.0495	1.98	0.0090	2.70	0.0011
0.56	0.1799	1.28	0.0475	2.00	0.0085	2.72	0.0010
0.58	0.1742	1.30	0.0455	2.02	0.0080	2.74	0.0009
0.60	0.1687	1.32	0.0437	2.04	0.0076	2.76	0.0009
0.62	0.1633	1.34	0.0418	2.06	0.0072	2.78	0.0008
0.64	0.1580	1.36	0.0400	2.08	0.0068	2.80	0.0008
0.66	0.1528	1.38	0.0383	2.10	0.0065	2.82	0.0007
0.68	0.1478	1.40	0.0367	2.12	0.0061	2.84	0.0007
0.70	0.1429	1.42	0.0351	2.14	0.0058	2.86	0.0006